The observed rotation in oxygen gives a value for this of $3{\cdot}5 \times 10^{-14}$, so that it is about equal to the calculated value.

The discrepancy may be due to the fact that ρ is not the same for all spectral lines, and we could not reasonably expect to get an accurate result by assuming that the Zeeman effect in zinc can be used in calculating the Faraday effect in oxygen. On the whole I think the calculation shows that what must be a *vera causa* for a Faraday effect is the whole cause of it. From the mere fact that rotatory polarisation is approximately inversely as the square of the wave-length and consequently vanishes for long waves, it follows that it is essentially a dispersion phenomenon.

"On artificial temporary Colour-blindness, with an Examination of the Colour Sensations of 109 Persons." By GEORGE J. BURCH, M.A. Communicated by Professor GOTCH, F.R.S. Received February 5,—Read February 17, 1898.

(Abstract.)

By exposing the eye for a sufficient length of time to bright sunlight in the focus of a burning glass behind suitably chosen transparent screens, it is possible to induce over the whole retina a condition of temporary colour-blindness.

After red light the observer is for some minutes completely red-blind, so that scarlet geraniums appear black and roses blue, while yellow flowers seem various shades of green, and purple flowers look violet. The same mistakes are made in sorting Holmgren's wools as by the red-blind.

Temporary violet blindness may be brought about by using a tank of ammonio-sulphate of copper. While it lasts, violet wools look black and purple flowers crimson, but the green foliage appears of a richer tint than usual. The recovery from violet blindness is very slow.

Green blindness may be brought about by exposing the eye to light through three thicknesses of green glass. The colour-scheme of the landscape during this condition is that of a picture painted with vermilion, flake-white, and ultramarine, variously blended.

Purple blindness may be produced by a combination of films stained with magenta and aniline violet, by which the green is absorbed. During purple blindness the vision is practically monochromatic, no colour being visible but green.

If one eye is rendered purple-blind and the other green-blind, the observer sees all objects in their natural colours but with a curiously exaggerated perspective due to the difficulty of combining the images perceived by one eye with those visible to the other.

General Appearance of the Spectrum during Temporary Colour Blindness.

A large spectroscope, in which only about a tenth part of the spectrum is visible at once, is directed to the sun, and the slit opened till the illumination is as intense as can be borne. After the eye has been sufficiently fatigued the results are observed in a single-prism spectroscope in which the entire spectrum is visible.

The following parts of the spectrum, namely, the red from A to B, the green from the neighbourhood of E, the blue about half-way between F and G, and the violet at and beyond H, produce well-defined and characteristic results, whereas the intermediate portions of the spectrum produce results intermediate in character.

That is to say, while exposure to red light causes changes affecting the red, and exposure to green light produces corresponding changes in the green, yellow light, instead of causing corresponding changes in the yellow, affects the whole of the red and the whole of the green, the total change being equal to the sum of the changes due to excitation by red light and by green light separately.

The effects produced by each of the four above-mentioned colours differ in degree but not in kind.

(1) In each case all direct sensation of the colour used for fatiguing the eye is lost.

(2) There is produced a positive after-effect of the same colour by which the hue of all other colours is modified if they are relatively weak, but which is unnoticed if they are bright.

(3) The temporary abolition of any one colour sensation is without effect on the intensity of the remaining colour sensations.

(4) Any two or any three of these four colour sensations can be simultaneously or successively exhausted.

(5) The positive after-effect of red is very transient; that of green lasts longer and is more noticeable; that of blue is still more powerful and persistent; and that of violet is strongest and lasts a long while. As the positive after-effect subsides the colour sensation returns, but the positive after-effect becomes unnoticeable long before the colour sensation is restored to its full strength.

(6) During the process of dazzling the eye the observer is conscious of the progress of the change, but only realises the extent of his colour blindness on attempting to examine a less brilliantly illuminated spectrum.

The positive after-effect does not in these experiments pass through cyclic changes of tint as after-images appear to do under other conditions.

Examination of the Phenomena with a Spectroscope of Wide Dispersion.

Green blindness was produced by the spectroscopic method already described. When the exposure was complete the slit was closed until the Fraunhofer lines were sharply defined. All sensation to green was lost, the red appearing to meet the blue in the centre of the field. The position of the junction of these two colours could be varied considerably by exposing the eye to strong red or strong blue light, thus showing that the red and blue overlap. But violet light had no effect upon the position of the junction of red with blue.

Similarly, during blue-blindness, the green and violet were seen to overlap, exposure to green light shifting the junction towards the green and *vice versa*. Red light had no effect on the position of the junction of green with violet during blue-blindness.

The phenomenon of flickering* visible between the red and the green of a highly magnified spectrum, is also seen at the junction of red with blue during green-blindness, and of green with violet during blue-blindness, as well as at the junctions of green with blue and of blue with violet under normal conditions.

The author has succeeded by an exposure of three minutes to light from between H and K in blinding the eye to violet without affecting the blue, the real hue of which is thus seen, unaccompanied by any other colour sensation.

These experiments lead to the conclusion that no one colour-sensation is related to any other in the sense indicated by Hering. Each may be exhausted without either weakening or strengthening the others. The observed facts are, in the author's opinion, more in accordance with the Young-Helmholtz theory, but they imply the existence of a fourth colour sensation, namely, blue.

Examination of the Colour Sensations of 109 *Persons.*

The tests employed were Holmgren's wools, supplemented by gelatine films stained with various colours, Hering's method of coloured shadows, and the author's spectroscopic method, which was applied to seventy normal cases in the following manner.

Using the large spectroscope referred to, with the slit narrow so as to give a comfortable degree of illumination, the observer selects those portions of the spectrum at which he sees a marked change of hue. He then looks at the red between A and B for thirty seconds, and at a given signal traverses the spectrum rapidly, stopping at the first of these changes.

Next he looks at the green for thirty seconds before turning to the

* 'Physiol. Soc. Proc.,' June, 1897.

second change of hue. Again, after looking at blue for thirty seconds he seeks the third change of hue. The next step is to trace the violet to its limits. After this he works through the spectrum back again, fatiguing the eye with violet before finding the blue, and so on, ending with the determination of the limits of the red. The degree of fatigue is so slight that he is quite unconscious of it.

The seventy cases examined in this way agree as to the number and mean position of the changes of hue, but they may be divided broadly into those whose colour sensations overlap and those whose colour sensations do not overlap, *i.e.*, those who find the changes of tint occur in the same place when working from red to violet as when returning from violet to red.

The first class includes persons both educated and uneducated whose avocations require them to compare colours. The second comprises all who fail with the closer shades of Holmgren's wools. Details are given of some in whom the green and violet are so far extended into each other that they see practically no pure blue, and it is suggested that these, and other differences in the relative intensity and extent of the colour sensations may account for the divergence of opinions among writers on the subject. The paper concludes with an account of five cases of red-blindness.

"On the Connection between the Electrical Properties and the Chemical Composition of different kinds of Glass." By Professor ANDREW GRAY, LL.D., F.R.S., and Professor J. J. DOBBIE, M.A., D.Sc. Received February 7,—Read February 17, 1898.

The experiments and results described in the following paper are a first instalment of work we have undertaken with a view to finally determining, if possible, the circumstances which affect the conductivity and specific inductive capacity of glass. It appeared from some experiments which were carried out by Professor T. Gray and ourselves some years ago,* that it might be of interest to have a number of glasses specially made up with a view to testing some of the conclusions then arrived at.

A result previously obtained by Professor T. Gray had shown that potash and soda lime glasses have a higher conductivity than flint glasses; this result had also been arrived at by Dr. Hopkinson. In particular it seemed desirable to ascertain whether by increasing the amount of lead oxide and diminishing the amount of soda, the conductivity would go on diminishing. We have experienced great

* 'Roy. Soc. Proc.,' No. 231, 1884.